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(54) Vehicle remote actuating system.

(57) Vehicle tyres (12) each contain a sender (14) including a microprocessor (40), a radio transmitter (42), a pressure detector (48) and a magnetic switch (47) for sending a radio signals indicating sender ID, pressure data and change of switch state. An on-board receiver unit (18) having a microprocessor (24) evaluates the transmitted data and displays pressure condition information. A portable magnet is placed near each tyre (12), in turn, to operate the magnetic switches (47), resulting in a sequential transmission of sender ID codes which allows the receiver unit (18) to learn the tyre position of each sender. An inertia switch (44) in the tyre (12) triggers a radio transmission and the receiver unit (18) considers the absence of a transmission when expected as a failure and displays a service needed message. A remote portable sender (16) transmits signals for door unlocking or locking, boot opening and interior light control. The receiver unit (18) responds to the signals and issues commands to appropriate actuators.

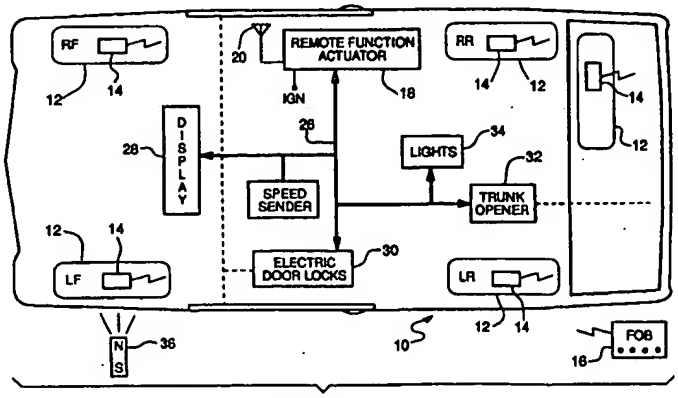

FIG - 1

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This invention relates to a vehicle remote function actuator system for detecting vehicle tyre pressure using facilities shared with another vehicle function, preferably a keyless entry control system.

It has previously been proposed to monitor tyre pressure by a transducer within each vehicle tyre. Several schemes have been tried for advising the vehicle operator of tyre pressure conditions, especially in the case of low tyre pressure. It is known, for example, to generate a visible signal at the tyre and to visually inspect the signal. It is also known to generate a magnetic field at the transducer in response to a low pressure condition, to detect the field by a detector mounted near each wheel, and to display a warning on the instrument panel. It has also been proposed to mount a transducer and radio transmitter within each tyre and a receiver on the vehicle dedicated to processing transmitted tyre pressure data and displaying necessary information.

The present invention seeks to provide an improved actuator system.

According to an aspect of the present invention, there is provided a vehicle remote function actuator system as specified in claim 1.

According to another aspect of the present invention, there is provided a method of operating an actuator system as specified in claim 5.

It is possible to coordinate with a radio transmission type of pressure data communication another vehicle function to reduce system expense as well as power drain on the vehicle battery, rather than a dedicated stand-alone receiver and processor unit.

Regarding the transmitter side of a radio transmission system, the energy for supplying the transmitter may be generated by tyre rotation, in which case information on a low tyre pressure condition occurring when a vehicle is not in use is not displayed until after vehicle movement begins. Alternatively, energy may be supplied by a battery, but then considerations of battery life come into play. It is desirable that battery life be very long, perhaps as long as vehicle life, while not compromising the amount or frequency of tyre condition information delivered by the system. Preferably, the system provides, in addition to data representative of low pressure condition, data representative of when correct pressure is restored, which tyre is affected, and of the operability of the transmitter unit.

It is possible to share receiver and processor tasks with another vehicle function to minimise system expense. Preferably, the system can display tyre pressure information specific to each tyre position and to update position data when tyres are installed and rotated. Advantageously, tyre pressure condition information is made available upon vehicle start-up and before vehicle movement. The system preferably optimises the availability of information on tyre pressure and the condition of transmitter units while minimising power consumption.

The preferred embodiment provides for sharing the receiver function with another vehicle operation to economise on initial expense as well as upon power requirements; and assigning an identification code to each transmitter, establishing a record of the tyre position of each transmitter and updating the record when tyres are rotated, so that pressure data can be related to a specific tyre position.

An automobile may be equipped with a radio receiver for receiving transmissions from remote senders serving a keyless entry function as well as a tyre pressure monitoring function, and a processor (microprocessor) associated with the receiver for decoding received signals and carrying out appropriate responses in the vehicle. The keyless entry senders may be a miniature control carried in the pocket or purse of a user for transmitting radio signals to the vehicle to effect door unlocking, boot opening, and interior illumination. The tyre pressure senders may be controllers mounted within a tyre for sensing tyre pressure condition for transmitting to the vehicle receiver information on pressure, the identification code of each sender and the condition of the sender itself. The signal format of the tyre pressure senders is preferably the same as the keyless entry senders. A code in the signal may identify the source of the signal. For a keyless entry function, the processor is preferably linked to door lock circuits, interior lighting circuits and to a boot opener for selectively responding to radio transmitted signals from the entry sender. For a tyre pressure monitor function the processor preferably controls an instrument panel display which shows tyre pressure messages visible to the vehicle operator.

In the case of the tyre pressure senders, a pressure switch, a magnetic switch, an inertia switch and optionally an analogue pressure sensor are preferably provided as inputs to a controller which drives a transmitter, all being powered by a long-life battery. To minimise energy consumption the transmitter may be turned off with the controller remaining in a sleep mode until a sensed event calls for transmission of data. When tyre pressure drops below a pressure switch setting or increases above the setting, that event may wake up the controller and a new pressure status transmitted to the receiver. Preferably, a state of health signal is sent to the receiver just to verify that the controller and transmitter are operational. This signal can be triggered periodically by a timer in the controller, but preferably an inertia switch is used to trigger the signal whenever the vehicle speed reaches

some vehicle speed such as 40 km/h (25 mph). If it is desired to report the tyre pressure value to the operator, an optional analogue sensor may be coupled to the controller and actuated by the controller whenever the inertia switch operates so that a pressure value is determined and transmitted to the receiver along with the state of health signal. Every data transmission preferably includes an identification code peculiar to the sending controller so that the receiver processor can relate the information to a particular tyre.

Magnet switches may be used to teach the receiver processor the location of each tyre on the vehicle, including a spare tyre. The magnetic switch may, for example, be a reed switch which changes state when affected by a magnetic field. A portable magnet can be carried by an operator and placed adjacent each tyre in a predetermined sequence. As each switch opens or closes it wakes up its associated controller to transmit the identification code to the receiver. The processor can then be apprised of the location of each tyre to make a record of that information. Then each time a low pressure or other signal is received from a tyre pressure sender the processor can identify the tyre position where the data originated. When tyres are rotated to different wheel positions the teaching process is repeated to update the tyre position data.

An embodiment of the present invention is described below, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of an embodiment of keyless entry and tyre pressure warning system;

Figure 2 is a schematic diagram of a remote function actuator of the system of Figure 1;

Figure 3 is a schematic diagram of a tyre pressure sender portion of the system of Figure 1;

Figure 4 is an illustration depicting the data format of radio communication used in the system;

Figure 5 is a flow chart showing an embodiment of operation of a tyre pressure sender; and

Figures 6-8 are flow charts showing an embodiment of operation of the receiver processor.

The ensuing description is directed to a system developed to combine a tyre pressure warning function and a keyless entry function using a common receiver and processor on the vehicle for implementing commands and displaying information in the vehicle. It should be understood, however, that the described embodiment may be implemented with other functions instead of or in addition to the keyless entry function sharing the receiver and processor for managing data originating either on board the vehicle or remote from the vehicle.

Referring to Figure 1, an automotive vehicle 10 has five tyres 12 at left front (LF), right front (RF), right rear (RR), and left rear (LR) positions and a spare tyre in the vehicle boot. Each tyre is equipped with a tyre pressure sender 14 residing within the tyre and subject to tyre pressure for transmitting radio signals carrying pressure related information. Each sender 14 has a unique identification code which is included in every transmission to help locate the source of pressure information. A portable remote keyless entry control or fob 16 small enough to be easily carried on the person of a vehicle operator transmits radio signals containing commands for unlocking doors, opening the boot or turning on the vehicle lights. A remote function actuator 18 carried on board the vehicle includes an antenna 20 for receiving the signals transmitted by the tyre pressure sender 14 and the fob 16. Figure 2 illustrates the actuator 18 as a radio frequency receiver 22 coupled to the antenna 20 and to a processor 24 which has a non-volatile memory such as an EEPROM 25. The processor is a microprocessor having a receiver-on port for sending a command to the receiver and a data port for accepting data from the receiver 22. The processor output is connected to a class 2 bus 26 which communicates with a vehicle display 28, electric door locks 30, a boot opener 32, and interior vehicle lights 34. A portable permanent magnet 36 is provided for use by the vehicle operator or service personnel for programming or teaching the actuator processor 24 the tyre positions occupied by the respective tyre pressure senders 14.

The tyre pressure sender 14, best shown in Figure 3, has a controller 40 and an FM transmitter 42, each powered by a battery 43, and a transmitter antenna 46. The controller comprises a microprocessor configured to maintain a sleep state requiring very low power consumption until it is awakened by some external event. The controller 40 has a data output coupled to the transmitter 42 for defining the transmitted signal, and a power output to the transmitter for turning on the transmitter only when a transmission is required, thus further saving battery energy. Inputs to the controller 40 are an inertia switch 44, a sign-up magnetic switch 47, a pressure switch 48 and optionally, a pressure transducer 50. The latter requires power so that a power line and a data line connect the transducer 50 to the controller 40 to impart analogue pressure measurements to the controller when power is furnished to the transducer. The matter of energy usage is important since the sender 14 is not easily accessible for battery replacement and the system should be designed to provide many years of battery life.

The inertia switch 44 is sensitive to tyre speed and is actuated when the tyre speed reaches a predetermined value which, for example, corresponds to a vehicle speed of 40 km/h (25 mph). The switch actuation prompts the controller to wake up momentarily and send a state of health message via the transmitter, and then return to the sleep state. The processor 24, in turn, notes each state of health message. In the event that a message is not received from each sender when the vehicle speed reaches a higher speed such as 57 km/h (35 mph), the processor displays a message such as "Service Right Front Pressure Sender Soon". Thus each tyre pressure sender is occasionally sampled to verify its operability. The analogue pressure data from each transducer 50 may be sent and displayed (or stored for later use) at the same time to update that information. Instead of the inertia switch, other means may be used to trigger a health verification. A timer could be operated for that purpose, but at the expense of energy consumption.

The sign-up magnetic switch 47 is operated by placing the magnet 36 near the tyre. When a magnetic switch is actuated the controller is awakened and causes a sign-up code as well as the identification code to be sent to the transmitter 42 and then to the actuator 18. By moving the magnet from one tyre to another in a prescribed sequence, the resulting sequence of transmissions enables the actuator to determine the position of each sender 14.

The pressure switch 48 is set to change state (open or close) at a suitable warning pressure. As the pressure in a tyre drops below the set pressure the switch changes state and the controller is awakened to cause transmission of a low pressure code. When pressure is restored to the tyre, the pressure switch reverts to its original state and the controller is awakened to transmit a pressure OK code. The processor 24 responds to the signals by displaying a low pressure or pressure OK message for that tyre.

Each time the controller is awakened it produces a short radio transmission and then resumes its sleep state. In the sleep state the controller draws 1 ma but when transmitting the sender requires about 3 ma. The transmitter employs frequency modulation with a carrier frequency of preferably 315 MHz. The data format is pulse width modulated. Both the data format and the message format are compatible with that of the fob 16 so that the receiver can consistently manage the data from either source.

The message format as shown in Figure 4 comprises a preamble which comprises a series of ones; a header one byte long for message byte forming and identifying the source as a tyre sender or a keyless entry fob; the unique transmitter identification code which is four bytes long; pressure data including seven bytes of zeros and 1 byte containing pressure measurements from the transducer 50 preferably covering a range of 0 kPa to 700 kPa (0 psi to 100 psi); a function code one byte long to denote sign-up, state of health, pressure low or pressure high, and finally a checksum 1 byte long for message verification. For the fob 16 transmission the function code would contain sign-up, door lock, door unlock, boot open, or light on commands, and the pressure data is replaced by security data which would comprise a code for verifying authenticity of the sending fob.

The process carried out by the controller is summarised by the flow chart of Figure 5. In the description of that flow chart and the subsequent flow charts, numerals in angle brackets, ⟨nn⟩, refer to the function of steps bearing corresponding reference numerals. According to the controller program, if the pressure switch changes state ⟨60⟩, and the new state is in the low pressure position ⟨62⟩, the low pressure message is transmitted ⟨64⟩. If it is not in the low pressure position, a pressure OK message is transmitted ⟨66⟩. If the pressure switch has not changed but the inertia switch is closed ⟨68⟩ a state of health message is transmitted ⟨70⟩. If the inertia switch has not closed and the magnetic switch has closed ⟨72⟩, a sign-up message is transmitted ⟨74⟩. After any message transmission or if no switch has closed or changed state, the program returns to Start. It is to be understood that if the sender 14 is equipped with a pressure transducer, the pressure data will be a part of each transmission.

The transmitted data is evaluated by the processor 24. The operation of the processor is illustrated by the flow charts of Figures 6-8. The main processor loop is shown by Figure 6. Beginning at a Main Start, it determines if a message is detected ⟨76⟩, and whether it is a tyre pressure related message ⟨78⟩. If it is, a routine is entered for processing tyre pressure messages ⟨80⟩, otherwise a routine is entered for processing keyless entry messages ⟨82⟩. At the end of either routine the program returns to start.

Response of the processor to signals received from the fob is straight-forward. When the function code commands an action such as Lock Door, Unlock Door, Open Boot or Turn On Interior Lights, the processor issues a signal on the bus to activate the appropriate utilisation circuit.

The routine 80 for processing tyre pressure messages is shown in the flow chart of Figure 7. If the message is a sign-up message ⟨84⟩ a sign-up procedure is executed ⟨86⟩. If it is a state of health message ⟨88⟩, a state of health procedure is executed ⟨90⟩. That procedure counts failures to de-

tect a state of health message and to display a service message if three or four failures are accumulated for a given sender. If it is a low tyre pressure message ⟨92⟩ a low pressure warning is shown on the display ⟨94⟩ for the particular tyre position which sent the message as determined by the identification code incorporated in the transmission, and a record of sender 14 positions established in the sign-up procedure. Finally, if it is not a low tyre message ⟨92⟩ it must then be a pressure OK message from a tyre which was previously low, and a tyre OK message is displayed for the tyre position from which the message originated. The program then returns to the Main Start of Figure 6. Upon the receipt of a low pressure message or pressure OK message that information and the tyre position is stored in the EEPROM 25. If the vehicle is operating when the pressure message is received it is immediately displayed. In the event that the vehicle is not operating when the pressure message is received, the new data is retrieved from the EEPROM and the appropriate message is displayed when the ignition is turned on.

The sign-up procedure 86 is initiated by a person manually moving the magnet to each tyre, in turn, according to a prescribed sequence, say, LF, RF, RR, LR, and then Spare. This causes each sender 14 to transmit a sign-up message accompanied by the identification code (ID). A time delay, preferably up to two minutes, is permitted between each measurement to allow movement from tyre to tyre. This series of sign-up messages provides the processor an opportunity to store the codes and their order of receipt. As shown in Figure 8, when the first sign-up message is detected ⟨100⟩ the ID is saved as the temporary LF tyre ID, and a message is displayed acknowledging the sign-up message ⟨102⟩. Such a display may read "LF tyre PROGRAMMED. WAITING FOR RF TYRE", for example. Next a two minute timer is initialised ⟨104⟩. While waiting for another sign-up message ⟨106⟩ the timer is checked ⟨108⟩; if the time has elapsed the temporary ID is erased ⟨109⟩ and the routine returns to the beginning, otherwise the timer is updated ⟨110⟩. When another sign-up message is detected before timeout ⟨106⟩,the ID is saved as the temporary RF tyre ID and the appropriate message is displayed ⟨112⟩. The process of blocks 104 - 112 is repeated for tyre positions RR, LR, and Spare. If all five temporary IDs are recorded they are then transferred as permanent IDs in EEPROM memory ⟨114⟩, and the temporary IDs are erased ⟨109⟩. Thereafter this record is referred to for determining tyre position for any received ID. Any time the tyre positions are changed for tyre rotation or exchanging a tyre of the spare, the sign-up procedure must be repeated to update the EEPROM record of tyre positions.

It will thus be seen that combining the low tyre pressure warning and keyless entry systems to share a receiver affords economy in initial cost and energy use. By using a common communication format the receiving microprocessor can readily process the incoming data from either source. Other vehicle functions using radio frequency data communication can be added to the system or used instead of the keyless entry function. The low tyre pressure sender itself is economical in energy usage to afford long battery life. Even so, state of health reports, low tyre pressure warning, pressure OK advisories, tyre position programming, and analogue pressure measurements are provided.

The disclosures in United States patent application no. 08/208,322, from which this application claims priority, and in the abstract accompanying this application are incorporated herein by reference.

Claims

1. A vehicle remote function actuator system including a common on-board radio receiver assembly (18) comprising a radio receiver (20,22) mounted in the vehicle for receiving transmitted data; at least one radio frequency remote tyre transmitter unit (14) including a controller (40) coupled to the transmitter, a pressure detector (48) coupled to the controller and operative to provide tyre pressure condition data, the controller being operative to cause the remote tyre transmitter unit to transmit the pressure condition data; at least one remote vehicle function transmitter unit (16) for transmitting radio frequency vehicle function data; the remote transmitter units all including the same data format and distinctive codes for the or each tyre transmitter unit and vehicle function transmitter unit; the on-board radio receiver assembly including a processor (24) connected to a radio receiver (22) and coupled to a warning device and to a vehicle function device for responding to the received data, the processor being operative to provide a warning of pressure condition data when received data contains a distinctive code for a tyre transmitter unit and to activate the vehicle function device when received data contains a distinctive code for a vehicle function transmitter unit.

2. An actuator system according to claim 1, wherein the or a vehicle function transmitter unit is a remote entry transmitter unit operative to transmit door lock operation commands; and the processor (24) is operative to actuate one or more electric door locks on receipt of door lock operation commands from the remote en-

try transmitter unit.

3. An actuator system according to claim 1 or 2, wherein the warning device includes a display.

4. An actuator system according to claim 1, 2 or 3, comprising a plurality of remote tyre transmitter units each associated with a respective vehicle tyre, the controller of each remote tyre transmitter unit being operative to generate an identification code for transmission with the pressure condition data and including the user actuated switch (47) for effecting transmission of the identification code of the remote tyre transmitter unit; the on-board radio receiver including a memory for storing received identification codes from each remote tyre transmitter unit so as to differentiate data transmitted from various tyre locations.

5. A method of operating an actuator system according to claim 4 in a vehicle including a plurality of tyres each equipped with a remote tyre transmitter unit (14) and electric door locks (30), the method including the steps of detecting a tyre pressure condition in at least one tyre and generating tyre pressure condition data; receiving a signal from a remote transmitter; determining from the received signal whether the signal contains tyre pressure condition data or a door lock operation command; displaying tyre pressure information when the received signal contains tyre pressure condition data and actuating one or more door locks when the received signal contains a door lock operation command.

6. A method according to claim 5, wherein when the received signal contains tyre pressure condition data, the method includes the steps of determining from the signal the identification code of the transmitter and therefrom the position of the tyre associated therewith, and displaying the determined tyre position and the tyre pressure condition data.

7. A method according to claim 5 or 6, comprising the steps of presenting a magnet to each remote tyre transmitter unit in a prescribed order so as to actuate sequentially the switch of each remote tyre transmitter unit and thereby to transmit the identification code associated therewith, receiving each identification code, and storing the received codes in a manner so as to identify the tyre position for each code.

8. A method according to claim 5, 6 or 7, wherein the step of detecting tyre pressure condition includes detecting when tyre pressure falls below a predetermined value, the tyre pressure condition data including an indication as to whether tyre pressure is below the predetermined value; and generating a tyre pressure warning and an indication of the position of the tyre when the tyre pressure condition data indicates that tyre pressure is below the predetermined value.

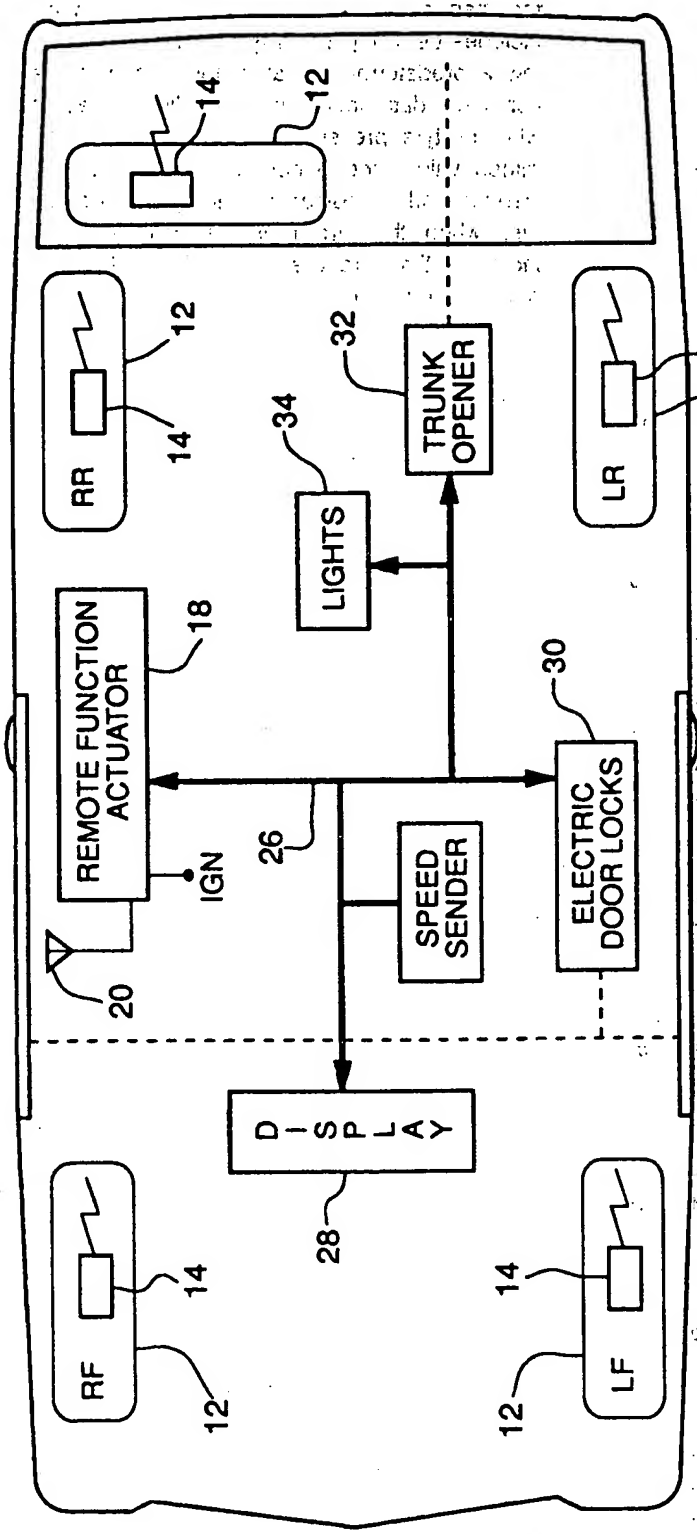

FOB
16
10
RR
LR
RF
LF
12
14
TRUNK OPENER
32
LIGHTS
34
REMOTE FUNCTION ACTUATOR
18
IGN
20
SPEED SENDER
26
ELECTRIC DOOR LOCKS
30
DISPLAY
28
N
S
36

FIG - 1


PREAMBLE
HEADER
ID
SECURITY / PRESSURE DATA
FUNCTION CODE
CHECK SUM

FIG - 4

FIG - 2

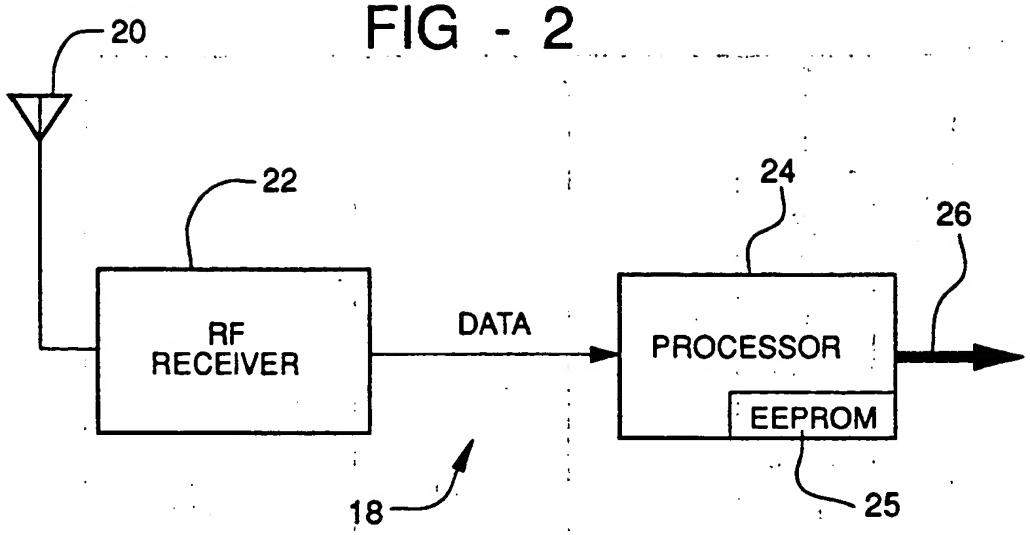

20
22
24
26
RF
RECEIVER
DATA
PROCESSOR
EEPROM
18
25

FIG - 3

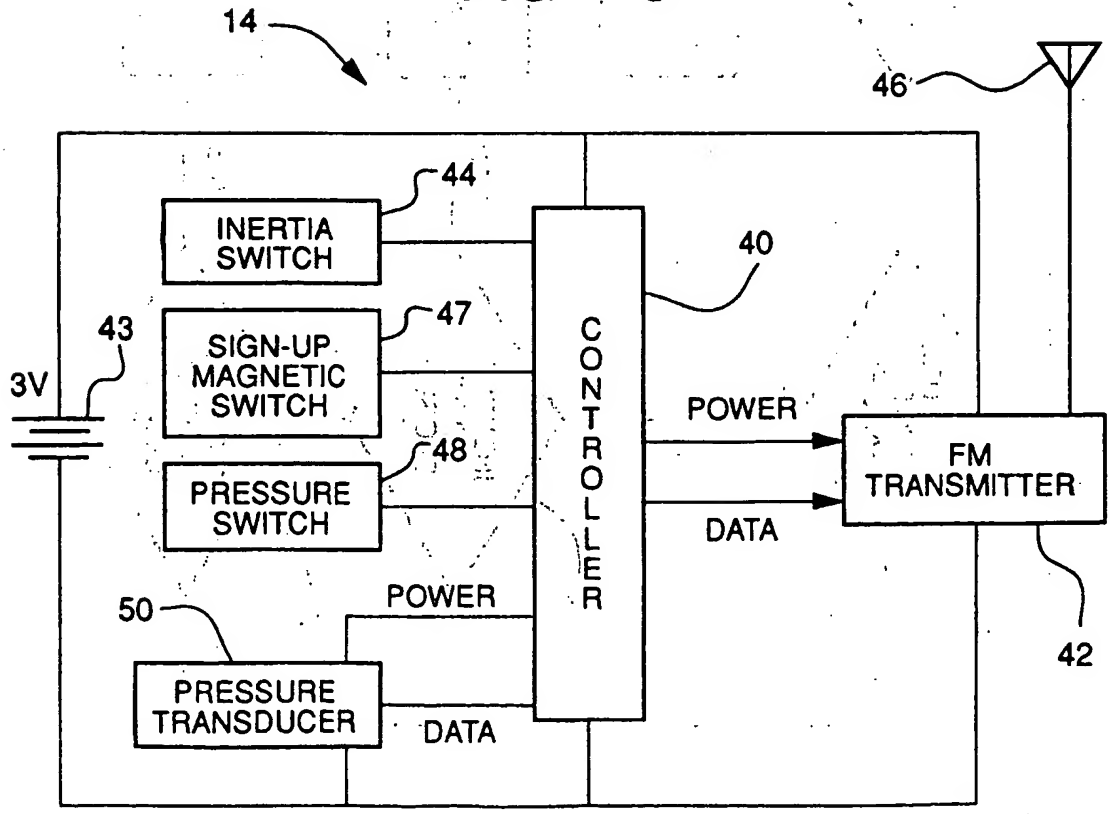

14
46
44
INERTIA
SWITCH
40
43
47
SIGN-UP
MAGNETIC
SWITCH
3V
CONTROLLER
POWER
FM
TRANSMITTER
48
PRESSURE
SWITCH
DATA
POWER
50
PRESSURE
TRANSDUCER
DATA
42

FIG - 5

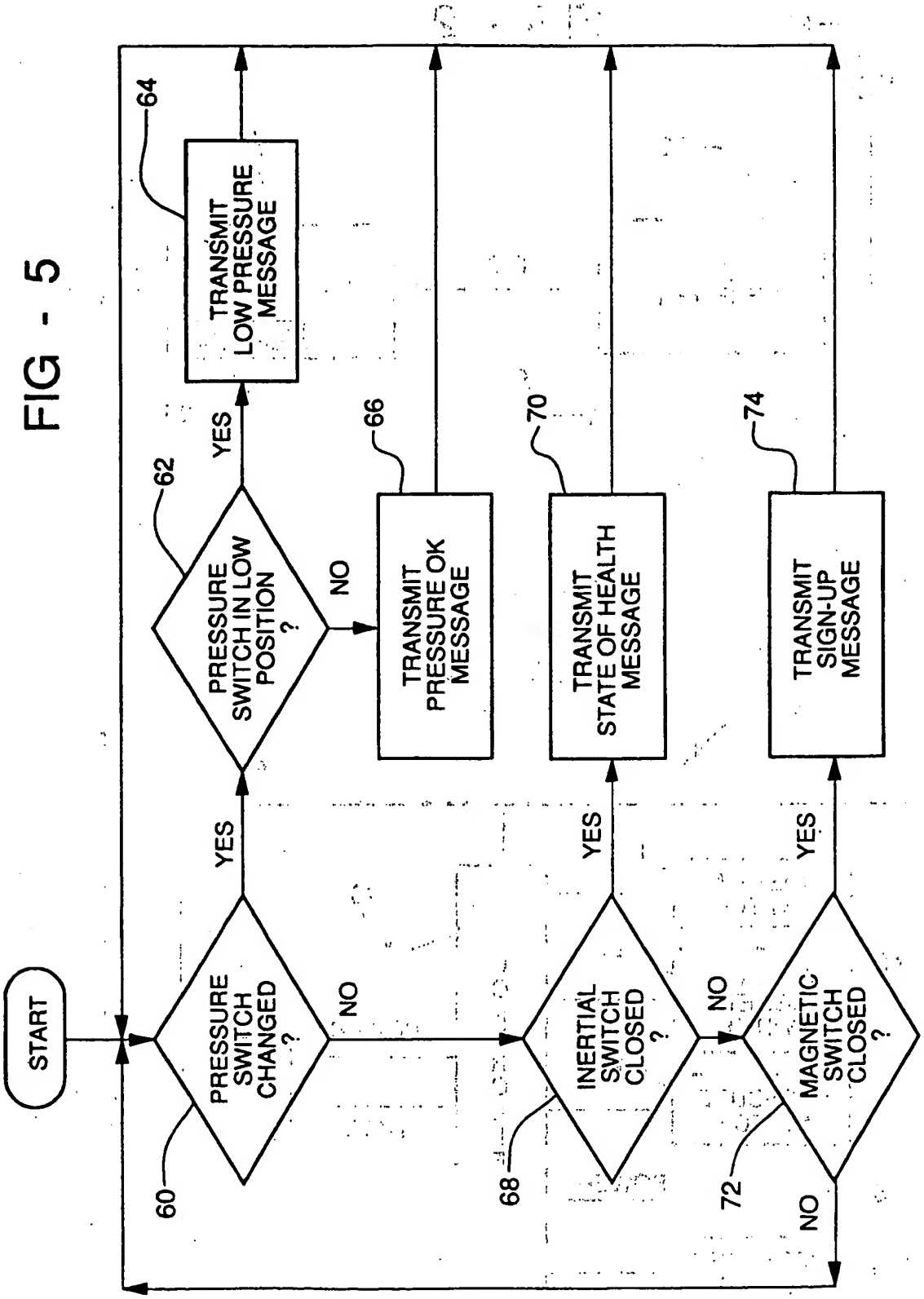

START
PRESSURE SWITCH CHANGED ?
YES
NO
60
PRESSURE SWITCH IN LOW POSITION ?
62
YES
NO
TRANSMIT LOW PRESSURE MESSAGE
64
TRANSMIT PRESSURE OK MESSAGE
66
INERTIAL SWITCH CLOSED ?
68
YES
NO
TRANSMIT STATE OF HEALTH MESSAGE
70
MAGNETIC SWITCH CLOSED ?
72
YES
NO
TRANSMIT SIGN-UP MESSAGE
74

FIG - 6

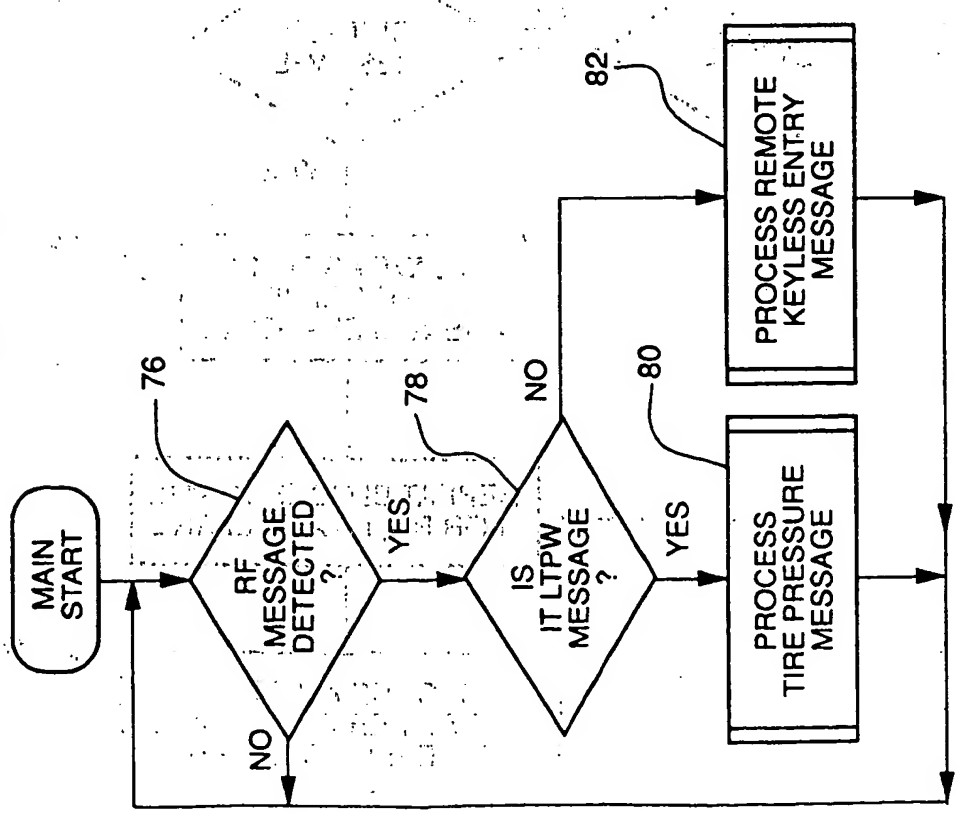

MAIN START
RF MESSAGE DETECTED ?
76
NO
YES
IS IT LTPW MESSAGE ?
78
NO
YES
PROCESS TIRE PRESSURE MESSAGE
80
PROCESS REMOTE KEYLESS ENTRY MESSAGE
82

FIG - 7

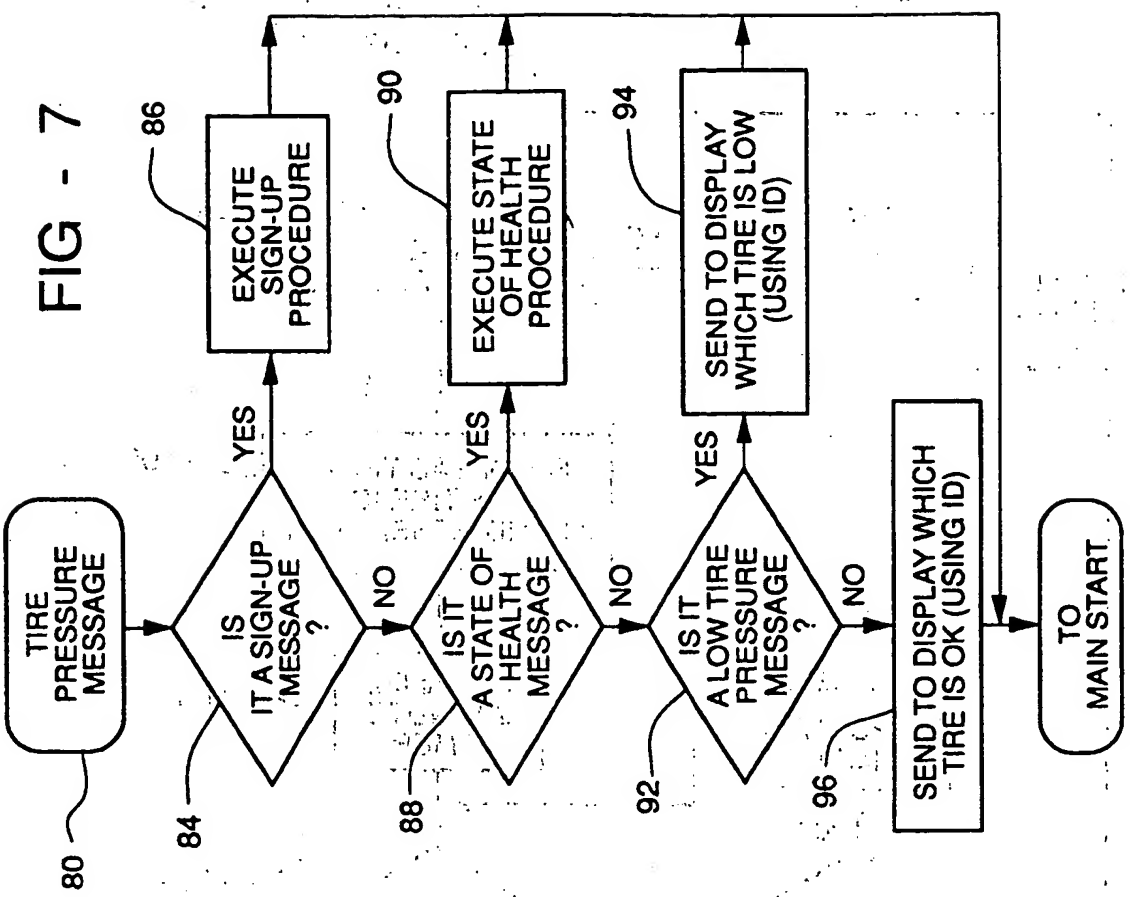
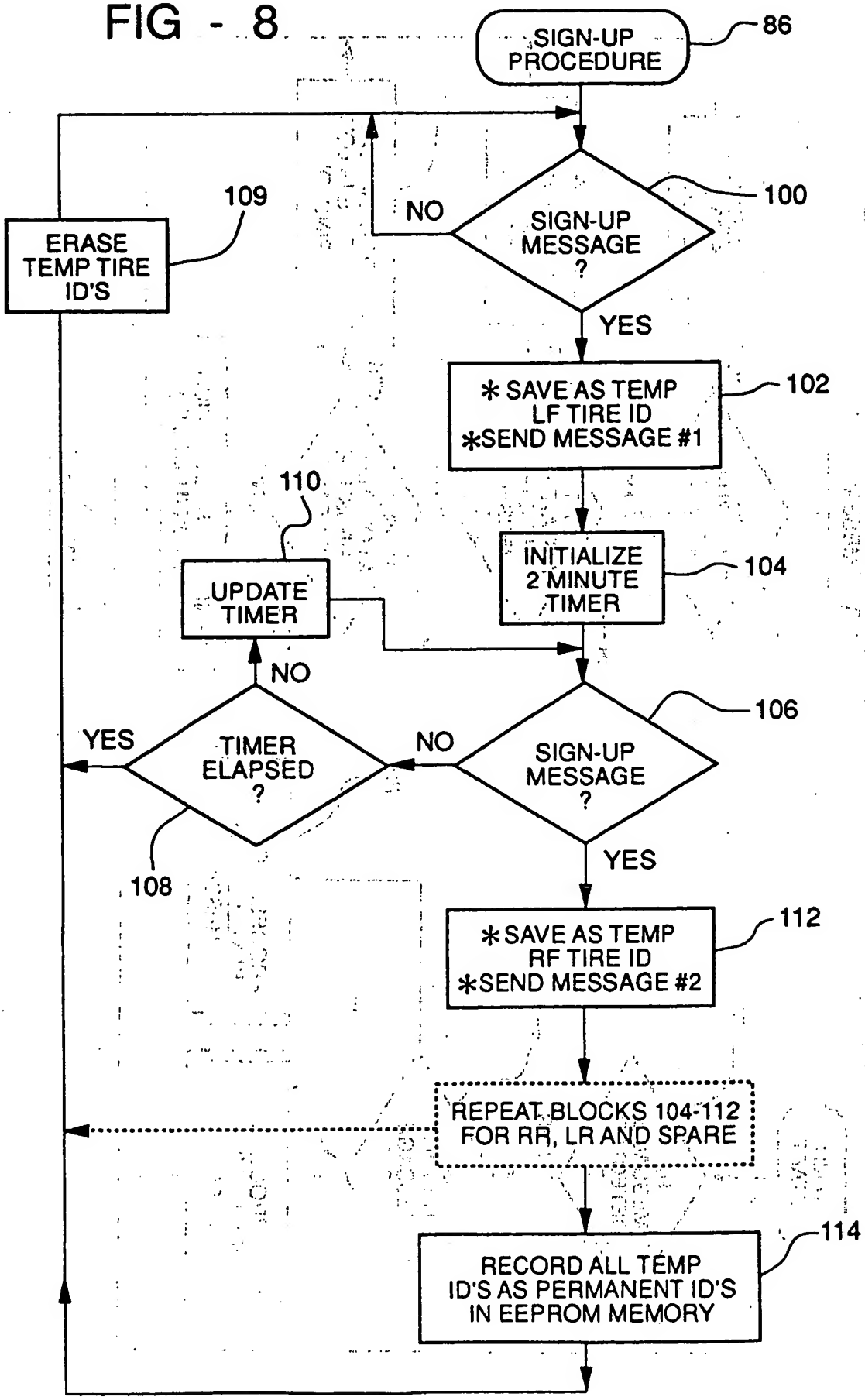

TIRE PRESSURE MESSAGE
80
IS IT A SIGN-UP MESSAGE ?
84
YES
NO
EXECUTE SIGN-UP PROCEDURE
86
IS IT A STATE OF HEALTH MESSAGE ?
88
YES
NO
EXECUTE STATE OF HEALTH PROCEDURE
90
IS IT A LOW TIRE PRESSURE MESSAGE ?
92
YES
NO
SEND TO DISPLAY WHICH TIRE IS LOW (USING ID)
94
SEND TO DISPLAY WHICH TIRE IS OK (USING ID)
96
TO MAIN START

FIG - 8


SIGN-UP PROCEDURE
86
SIGN-UP MESSAGE ?
100
NO
YES
ERASE TEMP TIRE ID'S
109
* SAVE AS TEMP LF TIRE ID
*SEND MESSAGE #1
102
INITIALIZE 2 MINUTE TIMER
104
UPDATE TIMER
110
NO
SIGN-UP MESSAGE ?
106
NO
TIMER ELAPSED ?
YES
108
YES
* SAVE AS TEMP RF TIRE ID
*SEND MESSAGE #2
112
REPEAT BLOCKS 104-112 FOR RR, LR AND SPARE
RECORD ALL TEMP ID'S AS PERMANENT ID'S IN EEPROM MEMORY
114

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 20 3647

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
P,X	EP-A-0 612 632 (KABUSHIKI KAISHA TOKAI RIKA DENKI SEISAKUSHO) * column 4, line 50 - column 5, line 6; figures; example *	1,2	B60C23/04
A	WO-A-92 20539 (EPIC TECHNOLOGIES) * abstract; figures 1,3 *	1,3	
A	EP-A-0 565 099 (T.S.S.) * page 7, line 46 - line 56; figures 1,3 *	1,4	
P,A	WO-A-94 18018 (ALPHA-BETA ELECTRONICS) * page 9, line 31 - page 10, line 26; figure *	6,7	
A	US-A-4 163 208 (MERZ) * abstract; figures *	7	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B60C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	9 June 1995	Hageman, L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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